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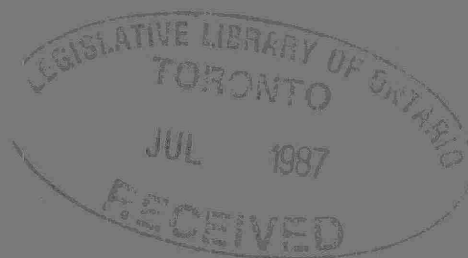
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SUITABILITY OF WATER QUALITY
IN TWO RECLAIMED LAKES
IN THE SUDBURY AREA
FOR MAINTAINING FISH POPULATIONS

TECHNICAL BULLETINS 6-78

APRIL 1978



Ontario

Ministry
of the
Environment

The Honourable
George R. McCague,
Minister

K.H. Sharpe,
Deputy Minister

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SUITABILITY OF WATER QUALITY IN TWO RECLAIMED LAKES
IN THE SUDBURY AREA FOR MAINTAINING FISH POPULATIONS

TECHNICAL BULLETIN 6-78[†]

by

W.F. Baksi, J. Richards, G. Craig, J. Reinke

Ontario Ministry of the Environment
Limnology and Toxicity Section
Water Resources Branch
Box 213, Rexdale, Ontario, M9W 5L1

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INTRODUCTION

Lakes in the Sudbury area have over the years suffered a decline in pH (Beamish et al, 1975; Beamish & Harvey, 1972) due to low buffering capacity and acid rain input. An Ontario Water Resources Commission report (1971) presented data indicating that lakes of unusually low pH and high heavy metal concentrations existed up to 40 miles distant from Sudbury. Lakes in the immediate vicinity of Sudbury, not obviously affected by acidic mine tailing runoff, have abnormally low pH and high sulphate levels (Gorham & Gordon, 1960). Since many of the affected lakes cited are in remote areas where no mine tailing effluents exist, it can be assumed that the changes in lake chemistry are a result of atmospheric input. Atmospheric input in the form of precipitation can influence the ionic chemistry of lakes as documented by Ericksson (1955), Gorham (1958, 1961), Gorham & Gordon (1960). The acidic rain may be produced when SO_2 is in contact with air-borne water producing H_2SO_3 and ultimately H_2SO_4 through further catalytic oxidation (Brosset, 1973).

The most apparent effects have been reported in other studies and include vegetation damage (Gorham & Gordon, 1960; 1963) and disappearance of fisheries (Beamish, 1974; Beamish & Harvey, 1972).

Investigations into the feasibility of reclaiming acidified lakes were initiated by the Ministry of the Environment in 1973. Four Sudbury area lakes having pH's of 4.5, in conjunction with high metal levels, (Scheider et al 1975), were neutralized and buffered with $\text{Ca}(\text{OH})_2$ and CaCO_3 . The application of these chemicals raised the pH to approximately 6.5 and dropped the metal levels in the water substantially (Scheider et al 1975). These chemical applications were repeated in 1974 and 1975 while the pH buffering capacity and metal levels of the lakes were monitored.

This report outlines work completed in the summer of 1975, to determine whether these reclaimed lakes would support a fishery. Three species of fish, rainbow trout, fathead minnows and pumpkinseed, were exposed to waters from two of the reclaimed lakes, Hannah and Lohi, while a third unaffected lake, Lake Panache, was used as a control.

METHODS

The onshore test facilities were located on private property at Lohi and Hannah Lakes. The control site at Lake Panache was on Ministry of Natural Resources property.

Six 270 litre exposure tanks, each fitted with a standpipe to maintain a volume of 135 litres, were located at each site. The exposure tanks were gravity-fed at a rate of 90 litres/hour by a 270 litre head tank fitted with an overflow to regulate the volume at a constant 200 litres. The head tank was supplied by a continuously operating submerged pump (Fig. 1). The water intake was located at a distance from the shore so as to be at least one meter above the lake bed and three meters below the surface. At Hannah Lake the intake was only one meter below the surface. At the control site three 1350 litre stock holding tanks were also supplied by a similar system. No temperature control was implemented at any of the sites. Three of the exposure tanks at each site were used for acute exposure periods lasting eight days each for rainbow trout (*S. gairdneri*) and fifteen days each for the pumpkinseeds (*Lepomis gibbosus*) and minnows (*P. promelas*). An additional group from each species was exposed for a period of 84 days to determine chronic effects. The acute and chronic studies incorporated 20 fish of each species, except for the first 3 chronic exposures in which 30 trout were used.

Pumpkinseed sunfish were purchased from Goossen's Trout Farm, Otterville, Ontario; rainbow trout fingerlings were obtained from Sandfield's Hatchery on Manitoulin Island; the fathead minnows were collected from a Toronto golf course pond. The fathead minnows and the pumpkinseed sunfish were treated with aquaflavin (4 mg/l) for 24 hours after being transported to the control site. The rainbow trout fry were not treated. Stocks were then acclimated a minimum of 14 days to the control water before distribution to the experimental lake sites. Longer periods of acclimation were necessitated if the fish were not feeding and/or were showing symptoms of disease. No fish were moved to the exposure sites if the mortality in the stock tanks exceeded 4% over the five days preceding the stock date.

Fish were fed twice daily, dead fish were removed upon inspection and tanks were cleaned daily.

Temperature, dissolved oxygen and pH of the incoming water was measured daily at all sites. Samples for the determination of total Al, Cd, Cu, Cr, Zn, Fe, Mg, Pb, Mn and Ni were taken once at Lake Panache to confirm previous sampling data; at the other lakes they were measured weekly. The same regime applied to samples for nutrients, acidity, alkalinity, conductivity and hardness.

The first 8 or 15 days of the chronic exposure, depending on species, was included with the acute mortality data and mean mortalities were compared by t-test analysis.

RESULTS AND DISCUSSION

Trout mortality in the acute exposure was significantly higher ($p < 0.05$) at both Hannah and Lohi Lakes than at Lake Panache (Table 1). Hannah Lake mean mortalities of 89.6% and Lohi Lake mean mortalities of 63.2%, clearly indicated that trout would not survive. Sunfish survived at all sites with no significant mortality (Table 2). Fathead minnow mortality occurred at all sites (Table 3) however, mortality was not significantly different ($p > 0.05$) among sites (Table 3).

Statistical analysis could not be completed on the chronic tests but they demonstrate results similar to the acute mortality tests (Table 4). The trout definitely would not survive at the test lakes, and experienced 53% mortality in control lakes. Mortalities for other species did not deviate greatly from controls, indicating a reasonable probability of survival (Table 4).

The most probable cause of trout mortality was undoubtedly temperature. Scott and Crossman (1973) indicate the optimum water temperature for trout as 10°C - 15°C, but add that rainbow trout can survive in habitats with temperature of 21°C or slightly lower provided a well oxygenated cooler water is available for retreat. Black (1953) states that the lethal temperature for Kamloops trout fingerlings, acclimated to 11°C, is 24°C. This value is applicable to our test organisms as they are of the same genus and species. The mean water temperatures of the three lakes (Table V) are well in excess of the upper tolerance limit of 20°C and approach the lethal limit of 24°C.

A second possible contributing factor to the observed mortality

could be the metal content of the experimental lakes. Though concentrations of most metals determined in the test waters were low, the combined effect of several metals could be sufficient to cause mortality (Sprague, 1965 and Ramsey, 1965). Additionally, metal toxicity and synergism is increased when water hardness is low (Bandt 1946, Doudoroff 1952) as the more toxic ionized (Trama 1959) state is favoured under these conditions due to low levels of competing ions. Hardness measured in the three lakes varied from 25 to 55 mg l⁻¹ as CaCO₃ (Table 6). However, it is not possible to quantitate the contribution of metals to the observed mortality as the temperature factor was probably the most predominant.

Our study indicates that the pumpkinseed sunfish are the most hardy and the most likely to survive. Fathead minnows, being more sensitive to copper than sunfish (Pickering & Henderson, 1966) showed higher mortality at all sites with the highest mean mortality of 25% over 84 days at Hannah. This was not significantly different ($p > 0.05$) from the control lake and indicates that the minnows would probably survive in the test lakes.

Table VII compares the D.O. values at the three lakes for the exposure tanks of the three species over the various exposure periods. At no time were the levels of dissolved oxygen below the critical value of 60% of saturation in any of the tanks. The pH values, Table IX, never dropped to values which would have been deleterious (pH 6) to the three species of fish exposed. The D.O. and pH did not differ significantly at either test site from the control ($p > 0.05$). All other water quality parameters of the three lakes (Table III) were well within the range expected for their geographical location (Craig and Baksi 1977) and would not have placed a stress upon the fish.

In conclusion, the reclaimed lakes appear to be able to support a hardy warm water fish, such as the sunfish or other centrarchid. The probability of fathead minnow survival is slightly less.

Further studies are required to determine whether a food source exists for these species and whether the water quality of these lakes is adequate for reproduction to occur, as both these factors are paramount to a successful fishery.

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TABLE 1. % Mortality of Rainbow Trout at the control site Lake Panache, and the test lakes Hannah and Lohi (20 fish/tank).

Run	Days	Panache	Hannah	Lohi
1	8	7%	93%	93%
2	8	0%	90%	100%
3	8	77%	100%	73%
4	8	15%	80%	35%
5	8	0%	85%	15%
	$\bar{x}$ mortalities	19.8%	89.6%	63.2%

TABLE 2. % Mortality of Pumpkinseed at the control site Lake Panache, and the test lakes Hannah and Lohi (20 fish/tank).

Run	Days	Panache	Hannah	Lohi
1	15	0%	0%	-
2	15	0%	10%	-
3	15	0%	5%	0%
4	15	0%	0%	0%
5	15	0%	0%	0%
	$\bar{x}$ mortalities	0%	3%	0%

TABLE 3. % Mortality of Fathead Minnow at the control site Lake Panache and the test sites lakes Hannah and Lohi (20 fish/tank)

Run	Days	Panache	Hannah	Lohi
1	15	5%	20%	10%
2	15	5%	20%	0%
3	15	20%	15%	5%
4	15	0%	25%	10%
5	15	0%	0%	0%
	$\bar{x}$ mortalities	6%	16%	5%

TABLE 4. Comparison of 84 day chronic exposure mortality, expressed as %, of the 3 test species at the 3 lakes

Lake	Trout	Pumpkinseed	Minnow
Panache	53	0	10
Hannah	100	10	20
Lohi	100	0	15

TABLE 5. Average of daily water temperature readings (°C) over exposure period in the trout tanks at the 3 lakes.

Run	Days	Panache	Hannah	Lohi
1	8	22.3	22.7	23.6
2	8	22.3	22.7	23.6
3	8	23.7	23.8	24.5
4	8	22.4	23.3	24.3
5	8	23.8	24.3	24.6

TABLE 6. Free metal content of water in test tanks at the 3 lakes. Values are expressed as ppb and are the mean values of all measurements made. Values for Hannah and Lohi are from Scheider et al 1976

Metal	Panache	Hannah (min-max)	Lohi (min-max)
Cu	6 (<0.001-0.018)	11 (6-15)	9 (3-18)
Zn	6 (<0.001-0.012)	23 (9-45)	16 (7-35)
Cd	<1 (-)	<0.3 (-)	<0.1 (-)
Pb	<1 (-)	<0.3 (-)	<0.3 (-)

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TABLE 5a. Average daily water temperature readings, in °C, over exposure period in tanks containing Pumpkinseed and minnows at the 3 lakes

Run	Days	Panache	Hannah	Lohi
1	15	20.4	21.3	22.2
2	15	23.0	23.1	23.8
3	15	24.4	24.9	25.4
4	15	22.5	22.8	23.3
5	15	20.4	21.5	21.9

TABLE 6a. Total metal content of water in test tanks at the 3 lakes. Values are expressed as ppb and are the mean of five samples for L. Panache. Values for Hannah and Lohi are from Scheider et al 1976.

Metal	Panache (min-max)		Hannah (min-max)		Lohi (min-max)	
Copper	7.5	(6-8)	58	(30-110)	42	(26-56)
Nickel	33	(27-37)	350	(300-400)	161	(120-240)
Lead	<3.0	(-)	<0.003	(-)	<3.0	(-)
Zinc	~12	(11-13)	32	(24-43)	25	(18-37)
Cadmium	<1.0	(-)	<3.0	(-)	<1.0	(-)
Chromium	<3.0	(-)	<3.0	(-)	<2.0	(-)
Aluminum	<3.0	(-)	<3.0	(-)	101	(43-210)
Manganese	3.0	(3-3)	180	(120-230)	160	(110-250)
Iron	18	(16-26)	87	(19-150)	96	(57-150)
Magnesium	2,300	(2000-2300)	3,900	(3000-4000)	1,000	(1000-1000)

TABLE 7. Dissolved oxygen in the tanks of the 3 species at the 3 lakes. Values are expressed as ppm and are the mean values of all measurements made over the exposure period

Run	Days *	Panache			Hannah			Lohi		
		Trout	Pumpkinseed	Minnow	Trout	Pumpkinseed	Minnow	Trout	Pumpkinseed	Minnow
1	15	9.2	8.6	9.4	7.9	6.5	7.7	7.8	6.0	8.2
2	15	8.8	8.3	8.8	8.1	7.3	8.3	7.9	6.9	8.2
3	15	8.6	8.2	8.8	8.5	7.8	8.7	8.3	7.5	8.3
4	15	8.9	7.9	8.8	8.8	8.0	8.9	8.3	7.3	8.6
5	15				9.1			8.2		

*Exposure periods for Trout were 8 days.

TABLE 8. Water quality parameters of the 3 lakes used. Values are expressed as ppm unless otherwise stated and are the mean values of 2 measurements for Lake Panache. Data for Hannah and Lohi Lakes are from Scheider et al 1976

Parameter	Panache	Hannah (min-max)		Lohi (min-max)	
Alkalinity	10.75	7.0	(3.0-8.5)	5.4	(4.5-6.5)
Hardness	26.0	66	(61-69)	27	(24-29)
Conductivity	69.3	206µmhos(195-215)		80µmhos (78-81)	
Sulfate	11.93	57.7	(43-75)	24.3	(20-27)
Free Ammonia	0.019	0.065	(0.010-0.030)	0.019	(<0.010-0.040)
Nitrites	0.001	0.009	(0.006-0.012)	0.002	(0.001-0.004)
Nitrates	0.095	0.51	(0.41-0.64)	0.053	(<0.010-0.150)
Kjeldahl N	0.29	0.230	(0.130-0.350)	0.168	(0.110-0.250)
Total Phosphorus	0.016	0.0036	(0.001-0.008)	0.0038	(0.001-0.008)
Dissolved Phosphorus	0.006				

TABLE 9. Mean daily pH values of test tank waters at the 3 lakes

Run	Days*	Panache			Hannah			Lohi		
		Trout	Pumpkinseed	Minnow	Trout	Pumpkinseed	Minnow	Trout	Pumpkinseed	Minnow
1	15	7.28	7.06	7.12	6.90	6.60	6.80	6.80	6.10	6.82
2	15	7.25	7.12	7.21	7.01	6.80	7.20	6.90	6.70	7.00
3	15	7.50	6.99	7.17	7.30	7.00	7.30	7.00	7.00	7.20
4	15	7.10	6.87	6.97	7.40	7.00	7.30	7.10	6.80	7.00
5	15	7.00	6.72	6.85	7.21	6.90	7.20	6.90	6.80	7.00

*Exposure periods for Trout were 8 days.

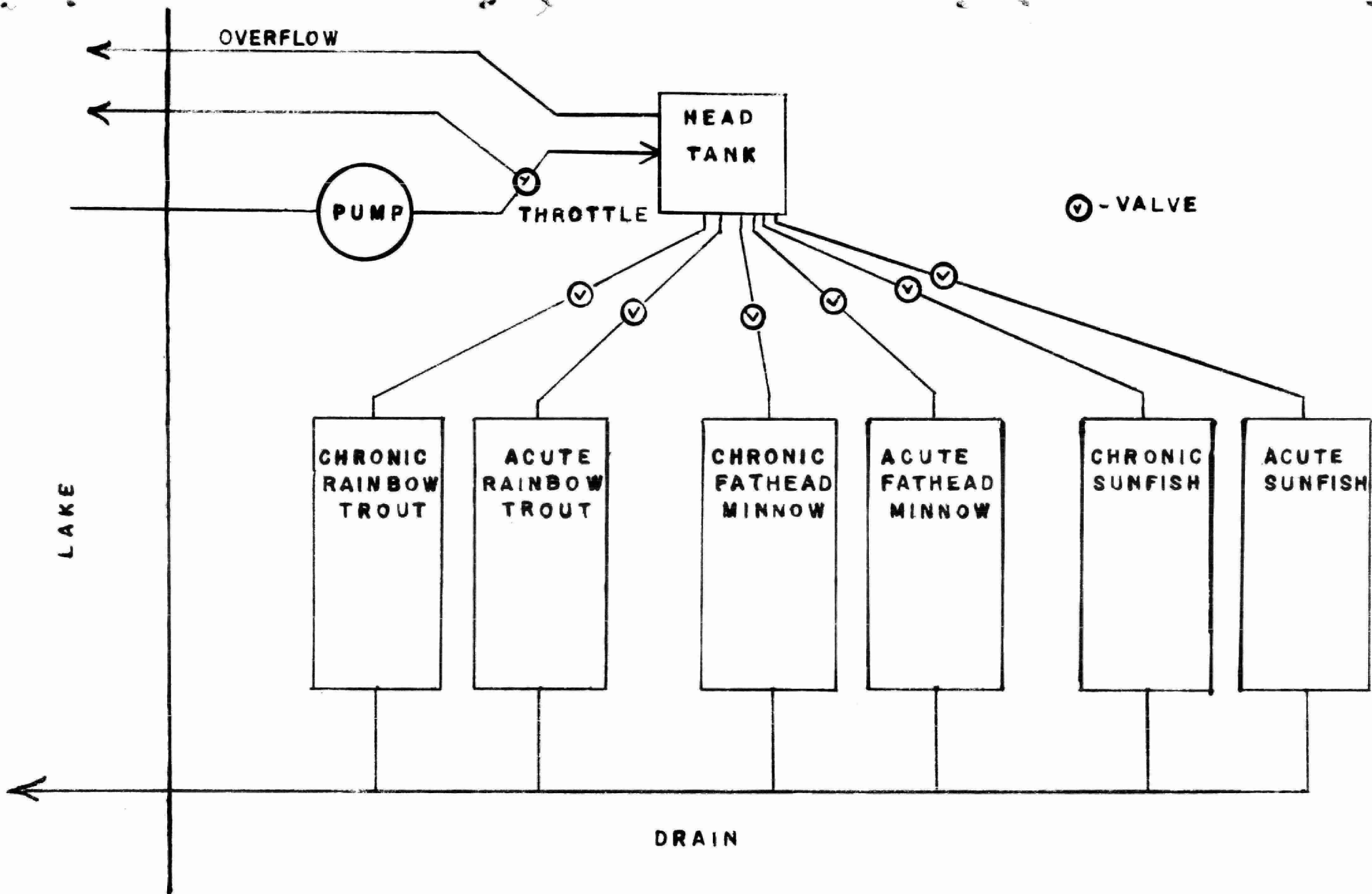


FIG. 1- EXPOSURE SYSTEM FOR CONTINUOUS-FLOW EXPERIMENTS



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